Electrical breakdown phenomena of dielectric elastomers

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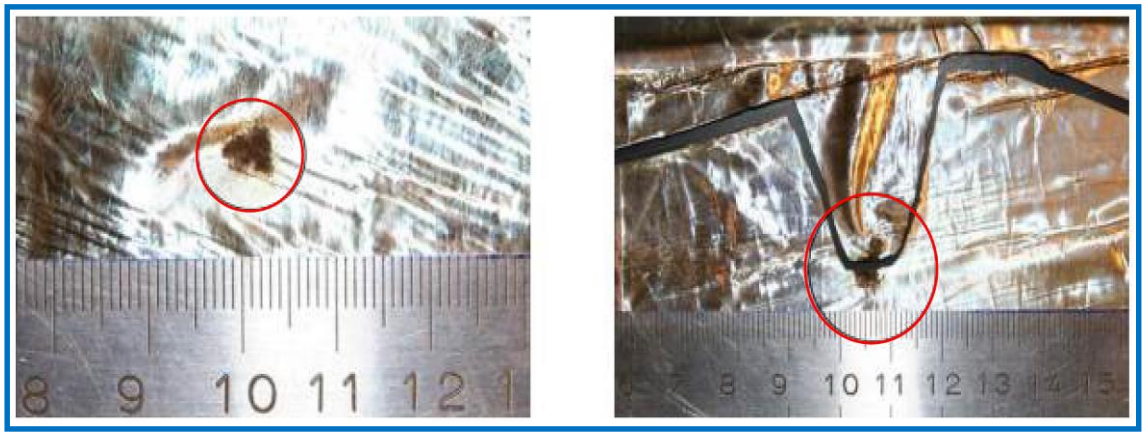

Figure 1. Electrical **breakdown** causes a **pinhole** formation on DEs film leading to major damage of the DE based devices.

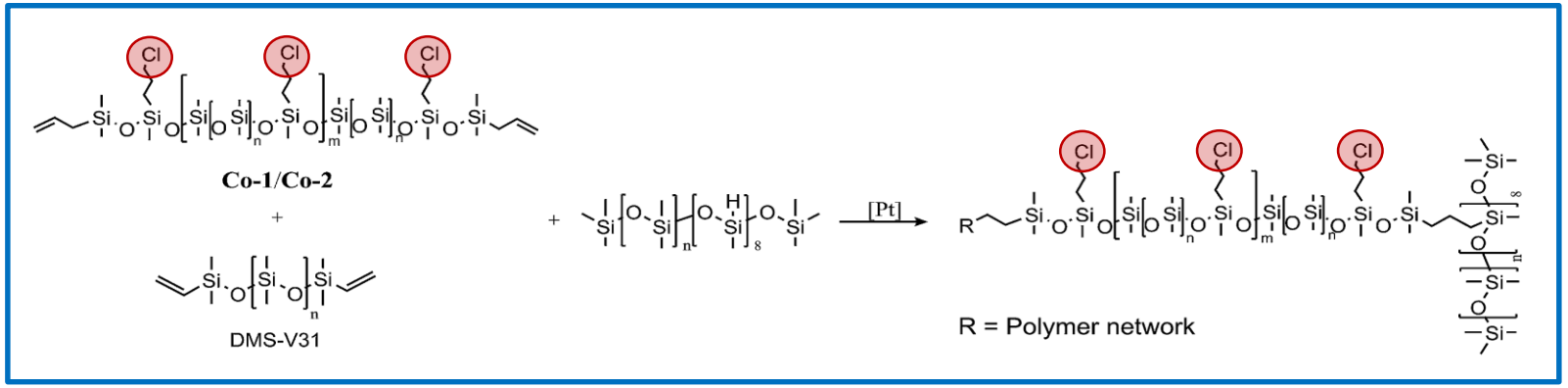

Figure 2. The structure of **chloro propyl** functional silicone elastomer.[1]

[1] F.B. Madsen, L. Yu, A.E. Daugaard, S. Hvilsted, A.L. Skov. *RSC Adv.* **2015**, *5*, 10254-10259.

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Scanning Electron Microscope (SEM) - Morphology

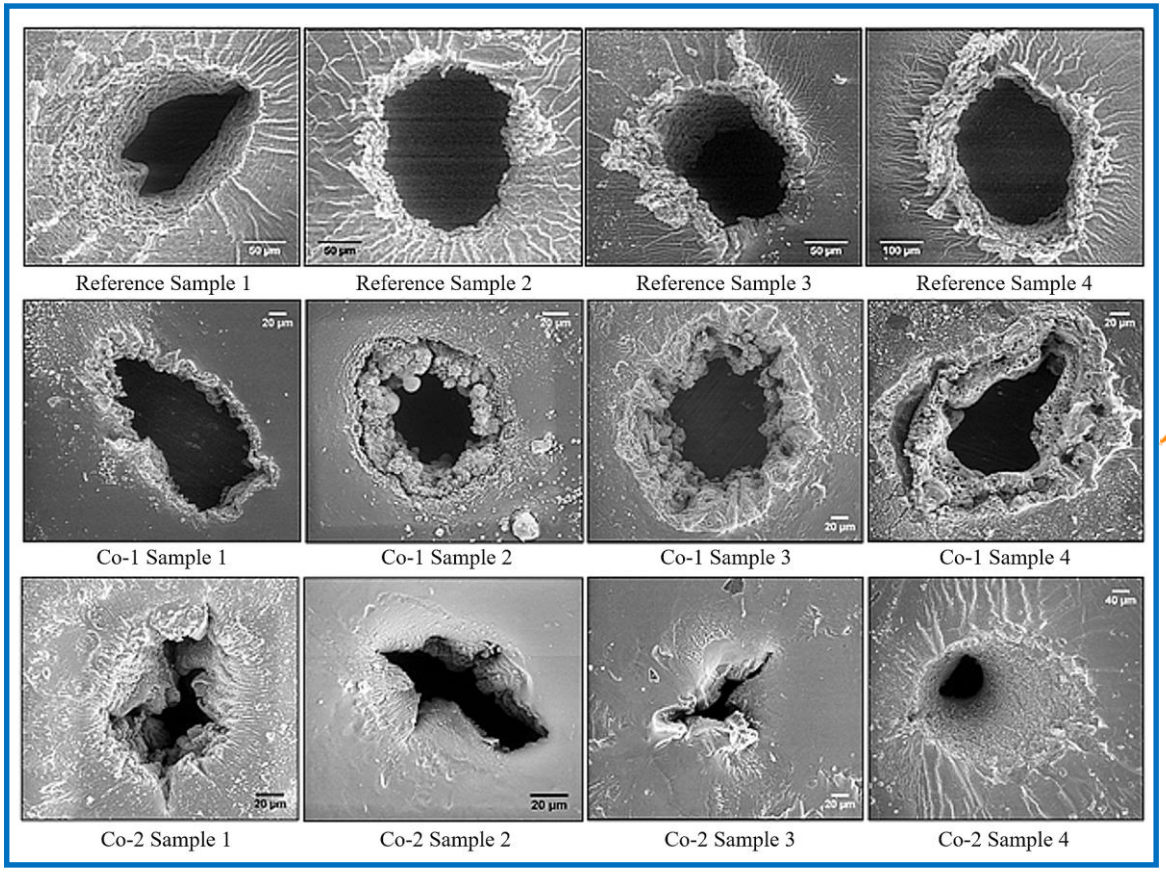

Figure 4. SEM images of breakdown zones for **reference samples**, **Co-1** and **Co-2** silicone elastomers. The black areas correspond to areas where the elastomer was completely removed during breakdown, i.e. pinholes.

Breakdown zones vary dimensionally with narrowest width to largest width:
Reference: **100-300** µm
Co-1: **60-100** µm
Co-2: **20-80** µm

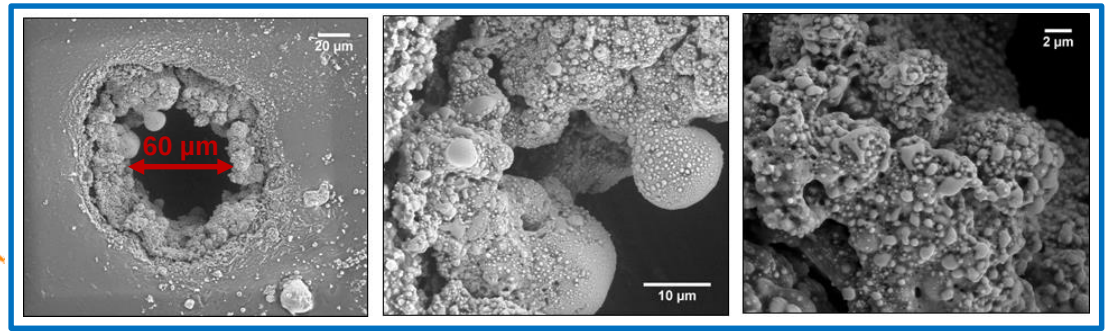

Figure 5. Illustration of **boiling nature** of the crosslinked copolymer **Co-1** in different magnifications. Droplets of condensing degradation products are formed on the surface of the breakdown zone.

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Energy Dispersive X-Ray Spectroscopy (EDS) - Elemental Distribution

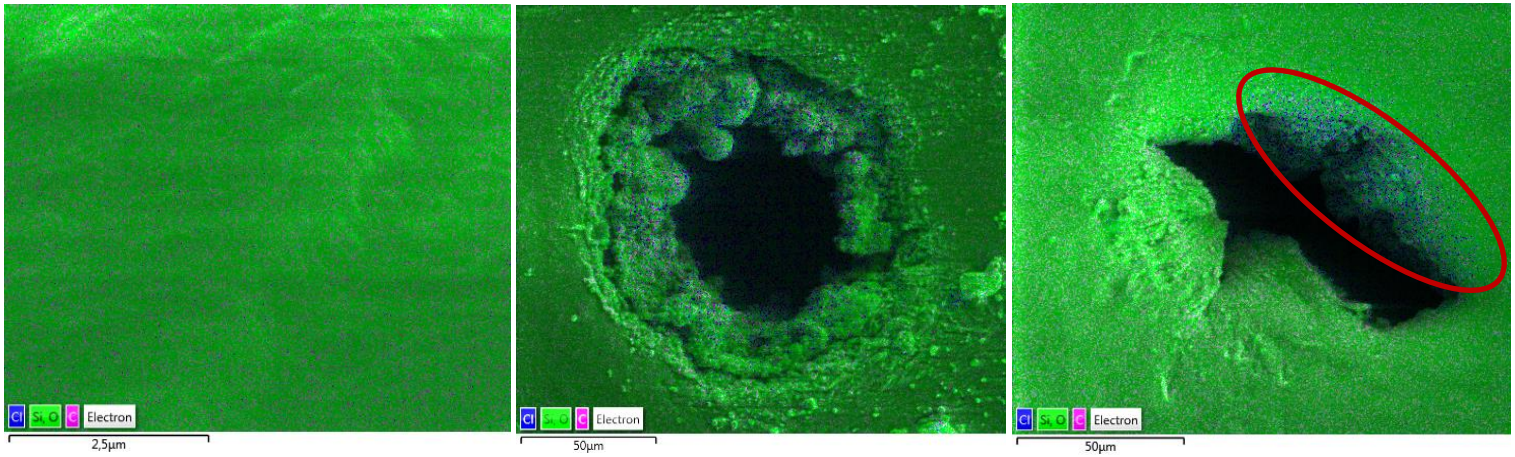

Figure 6. EDS mapping of **Co-2** elastomer surface where **Cl** is **uniformly distributed** (left), breakdown zones for **Co-1** (**middle**) and **Co-2** (**right**). The material in the **vicinity** of the **void** contains excess of **Cl** (blue color), which support the hypothesis that *silicon-containing substances have been evaporated off*.

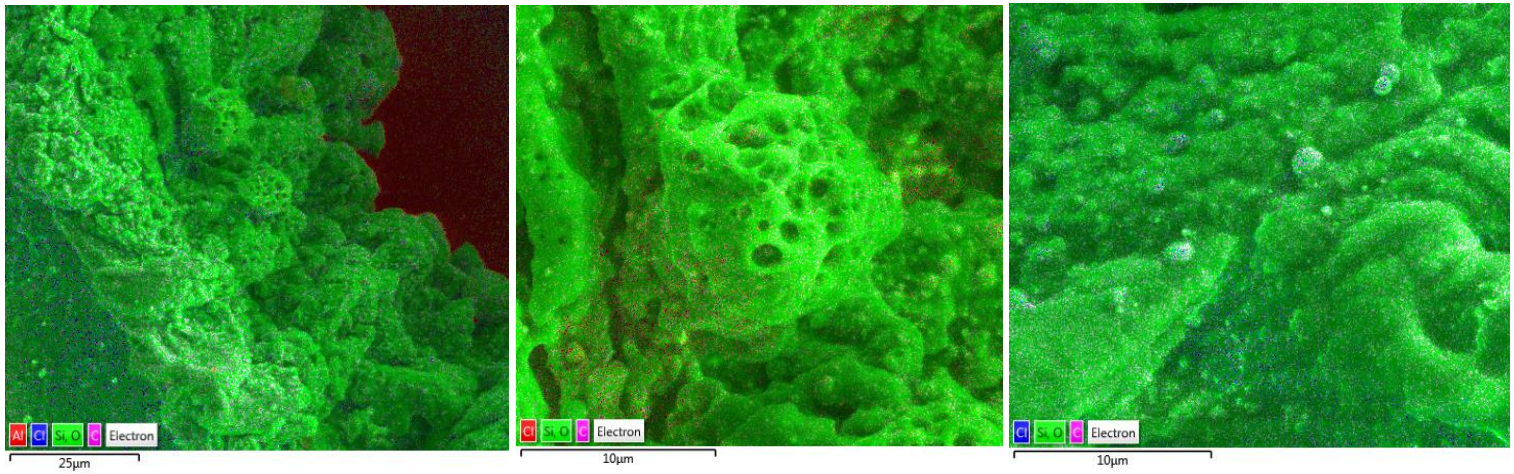

Figure 7. An increased concentration of Cl is recorded at the breakdown zones for the crosslinked copolymer Co-1.